# UM10014
# XenP202TT Series Designs User Manual

Rev.1.3 User Manual

## Introduction

This document introduces the ICLM high-precision multi-target detection mmWave sensor reference design XenP202TT, and the same series specific designs[1] CSP202TT and CSP203TT, including their basic functions, hardware specification, software configuration, and installing condition, etc.

This document aims to guide users to get started with the XenP202TT series multi-target detection solutions quickly and easily.



[1] The "specific design" means its technologies are mature and the application scenarios are specific; In addition, its parameters and functions are relatively well-tuned, and it is not recommended for the users to conduct further development.

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# 1. XenP202TT Series Designs Overview

Target tracking refers to tracking the position of a target in specified area in real time, and obtaining the distance, angle, and velocity of the target.

The XenP202TT series designs are high-precision multi-target detection mmWave sensor reference design/specific designs of ICLM EZ Sensor series. They contain minimalist 24 GHz radar sensor hardware Xen202, CS202_V2, and CS203_V1, and intelligent algorithm firmware TT01. This series reference/specific designs are mainly applied to positioning and tracking multiple humans in indoor scenarios such as homes, workplaces, and hotels.

The hardware incorporates AIoT mmWave sensor SoC S5KM312CL, high-performance 24 GHz 1T2R antennas, low-cost MCU, and peripheral circuits. The TT01 smart target tracking algorithm adopts FMCW and S5KM312CL specified signal processing technology.

Main features of the XenP202TT series designs are listed below:

- 24 GHz ISM bandwidth
- Integrate single chip smart mmWave sensor S5KM312CL and intelligent algorithm firmware
- Accurate human target positioning and tracking
- Compact module size:

  Xen202: 15 mm x 40 mm

  CS202_V2: 15 mm × 44 mm

  CS203_V1: 23 mm × 42 mm
- Environment temperature: -40°C ~ 85°C
- 5 V single power supply, also support 3.3 V power supply
- Maximum detectable range up to 8 m
- Azimuth angle ±60°, pitch angle ±30°
- Wall mounted

The XenP202TT series multi-target detection sensors can precisely position and track human body. They can be widely applied to various AIoT scenarios listed as follows:

- **Smart Home**

  Detect human presence, report results in real time, enable the MCU to control smart domestic appliances such as air-conditioner and fans accordingly;
- **Smart Business**

  Detect human approach or leaving in specified range to turn on/off devices;
- **Smart Bathroom**

  Enable smart toilets to automatically open and close the lid;
- **Intelligent Lighting**

  Detect human body presence and location precisely, applicable to domestic lighting (sensing lights, lamps, etc.)

# 2. System Characteristics

The XenP202TT series designs are high-precision multi-target detection mmWave sensor reference/specific solutions developed based on ICLM S5KM312CL. They detect human body in specified range and report the detection results in real time by incorporating FMCW, radar signal processing, and built-in intelligent positioning and tracking algorithm. With these reference/specific designs, users can quickly develop customized target tracking products.

## 2.1 XenP202TT Characteristics

The systematic characteristics of the XenP202TT are shown in Table 2-1.

Table 2-1 XenP202TT characteristics

| Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **Xen202 Hardware Characteristics** | | | | | |
| Supporting frequency | | 24 | - | 24.25 | GHz |
| Max. bandwidth | | - | 0.25 | - | GHz |
| Power supply | | 3.3 | 5 | 5 | V |
| Size | | - | 15 × 40 | - | mm × mm |
| Environment temperature | | -40 | - | 85 | °C |
| **XenP202TT System Characteristics** | | | | | |
| Detection range | | - | 8 | - | m |
| Range resolution | | - | 0.72 | - | m |
| Range accuracy | | - | 0.15 | - | m |
| Angle accuracy | | 2 | - | 20 | ° |
| Operating frequency | In accordance with FCC, CE and RC certification standards | 24 | - | 24.25 | GHz |
| Bandwidth | | - | 0.21 | - | GHz |
| Data refresh rate | Reporting frequency | - | 10 | - | Hz |
| Average Operating Current | | - | 125 | - | mA |

## 2.2 CSP202TT Characteristics

The systematic characteristics of CSP202TT are shown in Table 2-2:

Table 2-2 CSP202TT characteristics

| Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **CS202_V2 hardware Characteristics** | | | | | |
| Supporting frequency | | 24 | - | 24.25 | GHz |
| Max. bandwidth | | - | 0.25 | - | GHz |
| Power supply | | 3.3 | 5 | 5 | V |
| Size | | - | 15 × 44 | - | mm × mm |
| Environment temperature | | -40 | - | 85 | °C |
| **CSP202TT System Characteristics** | | | | | |
| Detection range | | - | 8 | - | m |
| Range resolution | | - | 0.72 | - | m |
| Range accuracy | | - | 0.15 | - | m |
| Angle accuracy | | 2 | - | 20 | ° |
| Operating frequency | In accordance with FCC, CE, and RC certification standards | 24 | - | 24.25 | GHz |
| Bandwidth | | - | 0.21 | - | GHz |
| Data refresh rate | Reporting frequency | - | 10 | - | Hz |
| Average Operating Current | | - | 111 | - | mA |

## 2.3 CSP203TT Characteristics

The systematic characteristics of CSP203TT are shown in Table 2-3.

**Table 2-3 CSP203TT characteristics**

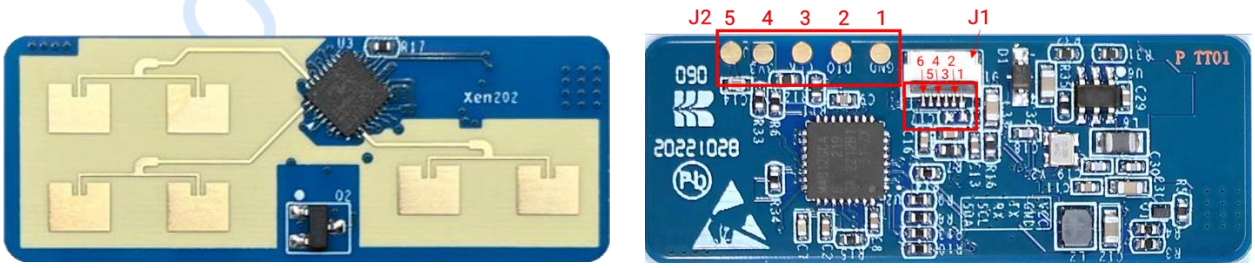
| Parameter | Condition | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **CS203_V1 hardware Characteristics** | | | | | |
| Supporting frequency | | 24 | - | 24.25 | GHz |
| Max. bandwidth | | - | 0.25 | - | GHz |
| Power supply | | 3.3 | 5 | 5 | V |
| Size | | - | 23 × 42 | - | mm × mm |
| Environment temperature | | -40 | - | 85 | °C |
| **CSP203TT System Characteristics** | | | | | |
| Detection range | | - | 8 | - | m |
| Range resolution | | - | 0.72 | - | m |
| Range accuracy | | - | 0.15 | - | m |
| Angle accuracy | | 2 | - | 20 | ° |
| Operating frequency | In accordance with FCC, CE, and RC certification standards | 24 | - | 24.25 | GHz |
| Bandwidth | | - | 0.21 | - | GHz |
| Data refresh rate | Reporting frequency | - | 10 | - | Hz |
| Average Operating Current | | - | 126 | - | mA |

# 3. Hardware Overview

This chapter introduces the device maps and interfaces of the high-precision multi-target detection mmWave sensor reference solution XenP202TT, the specific designs CSP202TT and CSP203TT.

## 3.1 Xen202 Hardware

Device maps of the hardware Xen202 are shown in Figure 3-1. Xen202 hardware reserves an FPC slot called J1 as power supply and communication interface; 5 pins called J2 as an interface for flashing MCU. When flashing the MCU for Xen202, connect the pins according to their names.




(a) Top (b) Bottom

**Figure 3-1 Top and bottom device map of Xen202**

Details of the J1 pins are listed in Table 3-1.

**Table 3-1 J1 pin description of hardware Xen202**

| J# Pin# | Name | Function | Operating Range |
|---|---|---|---|
| J1 Pin1 | VCC | Power input | 5 V or 3.3 V |
| J1 Pin2 | GND | Ground | - |
| J1 Pin3 | TX | UART_TX | 0 ~ 3.3 V |
| J1 Pin4 | RX | UART_RX | 0 ~ 3.3 V |
| J1 Pin5 | SCL | IIC clock | 0 ~ 3.3 V |
| J1 Pin6 | SDA | IIC data | 0 ~ 3.3 V |

*Note: The power supply design of the Xen202 series hardware[2] is shown in Figure 3-2. The default power supply is 5 V, in this case only the R36 is normally closed; this series hardware also supports 3.3 V power supply, in this case the R36 should be a 0 Ω resistor, and all the other DCDC peripheral circuit devices should be normally closed.*

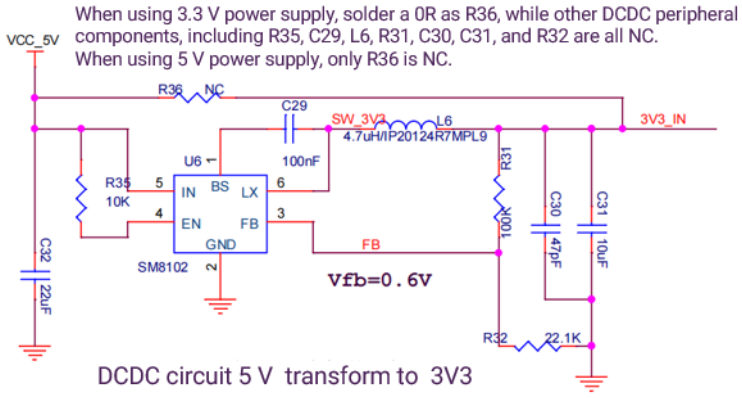



**Figure 3-2 Xen202 series hardware power supply mode**

When connecting the hardware, it is recommended to use an FPC soft cable to connect J1 slot with an FCP interposer board, then connect the interposer board with USB serial port. The recommended FPC interposer board and soft cable are shown in Figure 3-3.

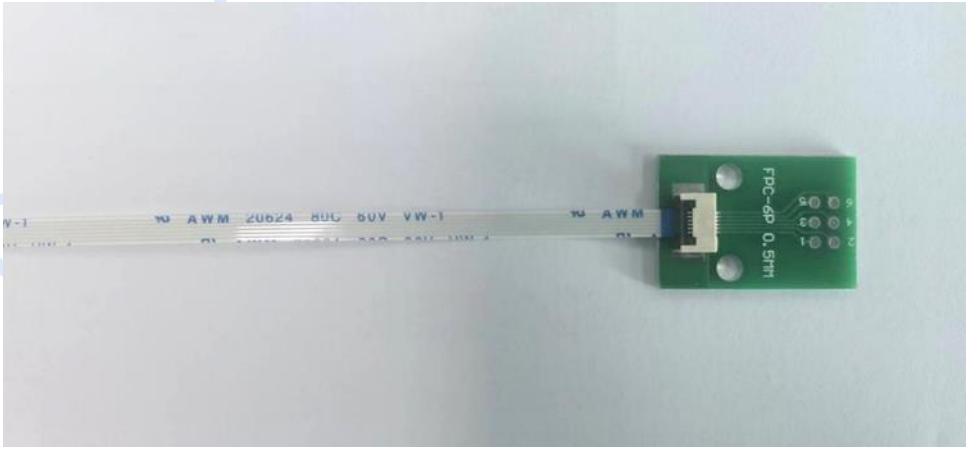



**Figure 3-3 FPC interposer board and soft cable**

The silkscreen number 1 ~ 6 on the interposer board is corresponded to each pin of J1, the mapping pattern depends on how the soft cable is used.

[2] The Xen202 series hardware includes Xen202 hardware, CS202_V2 hardware, and CS203_V1 hardware.

Details of the J2 pins are listed in Table 3-2.

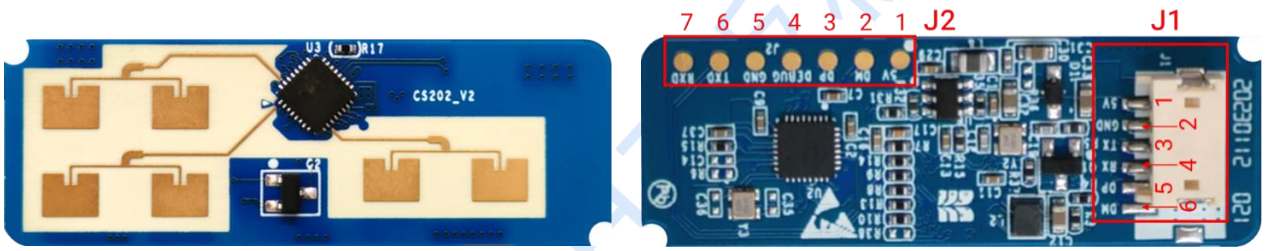
**Table 3-2 J2 pin description of hardware Xen202**

| J# Pin# | Name | Function | Operating Range |
|---|---|---|---|
| J2 Pin1 | GND | Ground | - |
| J2 Pin2 | DIO | Data port | 0 ~ 3.3 V |
| J2 Pin3 | CLK | Clock signal | 0 ~ 3.3 V |
| J2 Pin4 | 3V3 | Power input | 3.3 V |
| J2 Pin5 | reset | Reset signal | - |

Xen202 hardware supports flashing the program by Keil5 IDE, or flashing hex files by tools such as J-link and CMSIS-DAP. Before the programming, make sure relevant packs such as Nuvoton.NuMicro_DFP.1.3.12.pack and ARM.CMSIS.5.7.0.pack or later versions are installed.

## 3.2 CS202_V2 Hardware

Device maps of hardware CS202_V2 are shown in Figure 3-4 (a) and (b). The CS202_V2 hardware reserves a TXGA connector FWF15004 called J1 as power supply and communication interface; J2 for programming and testing, some of them share the same functions with some pins in J1.




(a) Top (b) Bottom

**Figure 3-4 CS202_V2 hardware device map**

Details of J1 and J2 are listed in Table 3-3 and Table 3-4.

**Table 3-3 J1 pin description of hardware CS202_V2**

| J# Pin# | Name | Function | Description |
|---|---|---|---|
| J1 Pin1 | 5V | Power input | 5 V |
| J1 Pin2 | GND | Ground | Connect to serial board GND |
| J1 Pin3 | TX | UART_TX | Connect to serial board TXD |
| J1 Pin4 | RX | UART_RX | Connect to serial board RXD |
| J1 Pin5 | DP | Positive signal of programing data | Not connected when using a 4-pin serial board |
| J1 Pin6 | DM | Negative signal of programing data | Not connected when using a 4-pin serial board |

**Table 3-4 J2 pin description of hardware CS202_V2**

| J# Pin# | Name | Function | Description |
|---|---|---|---|
| J2 Pin1 | 5V | Power input | 5 V |
| J2 Pin2 | DM | Negative signal of programing data | - |
| J2 Pin3 | DP | Positive signal of programing data | - |
| J2 Pin4 | DEBUG | Debug output | Serial port pin for outputting debugging log |
| J2 Pin5 | GND | Ground | - |
| J2 Pin6 | TXD | UART TXD | Connect to serial board TXD |

| | | | |
|---|---|---|---|
| J2 Pin7 | RXD | UART RXD | Connect to serial board RXD |

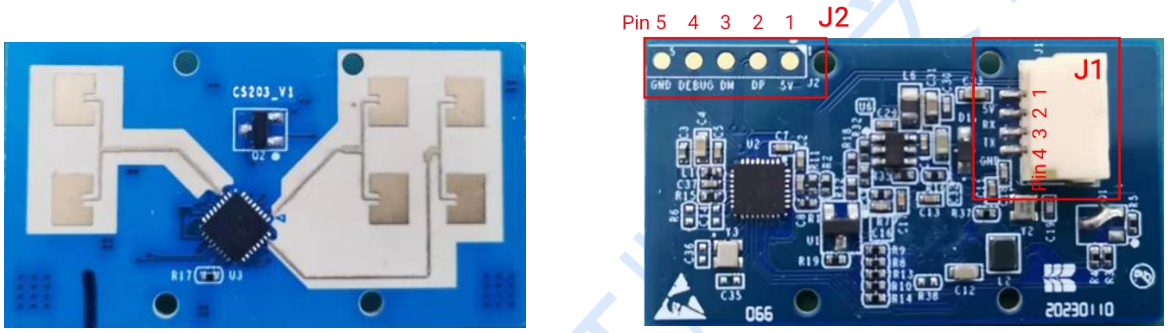
JL USB Updater is required to program CS202_V2 hardware. Jieli provides detailed tutorial on how to set up Jieli MCU developing environment and how to use the updater. The website of the tutorial is:

https://doc.zh-jieli.com/Tools/zh-cn/dev_tools/dev_env/index.html

*Note: The JieLi MCU does not support online debugging and only supports printing logs via serial port, therefore the debugging efficiency is low; in addition, developers should reserve a pin for debugging when designing the hardware.*

## 3.3 CS203_V1 Hardware

The device maps of hardware CS203_V1 are shown in Figure 3-5. The CS203_V1 hardware reserves J1 as a power supply and communication interface (J1 is a TE 2360545-C connector), and J2 as the MCU programming and debugging interface.




(a) Top (b) Bottom

**Figure 3-5 CS203_V1 hardware device map**

Details of J1 and J2 are listed in Table 3-5 and Table 3-6.

**Table 3-5 J1 pin description of hardware CS203_V1**

| J# Pin# | Name | Function | Description |
|---|---|---|---|
| J1 Pin1 | 5V | Power input | 5 V |
| J1 Pin2 | RX | UART_RX | Connect to serial board RXD |
| J1 Pin3 | TX | UART_TX | Connect to serial board TXD |
| J1 Pin4 | GND | Ground | |

**Table 3-6 J2 pin description of hardware CS203_V1**

| J# Pin# | Name | Function | Description |
|---|---|---|---|
| J2 Pin1 | 5V | Power input | 5 V |
| J2 Pin2 | DP | Positive signal of programing data | |
| J2 Pin3 | DM | Negative signal of programing data | |
| J2 Pin4 | DEBUG | Debug output TXD | Serial port pin for debugging |
| J2 Pin5 | GND | Ground | |

The hardware CS203_V1 is programmed through Jieli JL USB Updater. Jieli provides a detailed tutorial on how to set up Jieli MCU developing environment and how to use the updater, please refer to:

https://doc.zh-jieli.com/Tools/zh-cn/dev_tools/dev_env/index.html

*Note: The JieLi MCU does not support online debugging and only supports printing logs via serial port, therefore the debugging efficiency is low; in addition, developers should reserve a pin for debugging when designing the hardware.*

# 4. Software Overview

The Xen202, CS202_V2 and CS203_V1 hardware are released with the firmware TT01 programmed into the system. ICLM provides a software that can configure XenP202TT series radar modules from the host PC, and users can explicitly experience the target positioning and tracking functions of the radar module.

## 4.1 Software Description

ICLM_MTT.exe is a green software specially developed for XenP202TT, CSP202TT and CSP203TT. It displays and records radar data after connecting the XenP202TT series radar modules with a host PC.

Steps for connecting the software with the radar module are as follows:

Step 1: Download the software pack[3] from ICLM website, unzip it and enter the directory;

Step 2: Connect the radar module via suitable cable to the USB serial port tool and then connect the serial port tool to the host PC, detailed connection methods are as follows:

a) Connect the Xen202 module to a USB serial port tool using an FPC interposer board and FPC soft cable, as shown in Figure 4-1.

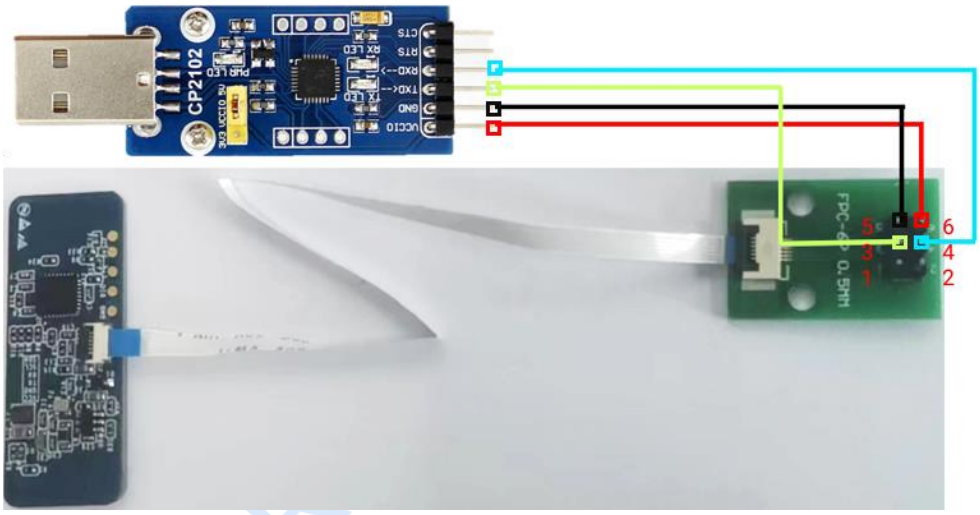



**Figure 4-1 Example of connecting the Xen202 hardware, interposer board, and USB serial port tool**

b) Connect the CS202 module to a USB serial port tool using Dupont threads, as shown in Figure 4-2;

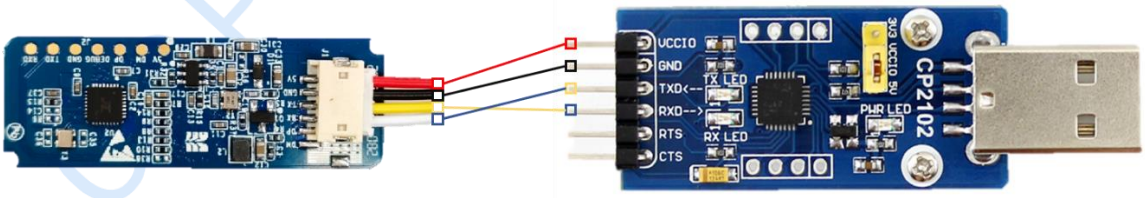



**Figure 4-2 Example of connecting the CS202 hardware to the USB serial port tool**

c) Connect the CS203 module to a USB serial port tool using Dupont threads, as shown in Figure 4-3;

[3] The software pack for the reference design XenP202TT is named *XenP202TT Target Tracking*, and those for the specific designs CSP202TT and CSP203TT are *CSP202TT Target Tracking*, and *CSP203TT Target Tracking* respectively.

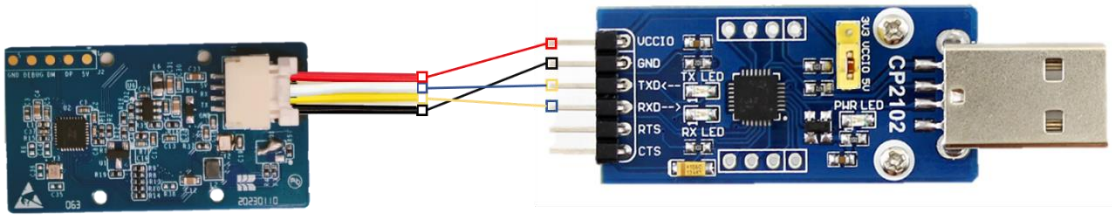



**Figure 4-3 Example of connecting the CS203 hardware to the USB serial port tool**

Step 3: Double click the **ICLM_MTT.exe** in the software directory, and the graphic user interface (GUI) will appear as shown in Figure 4-4.

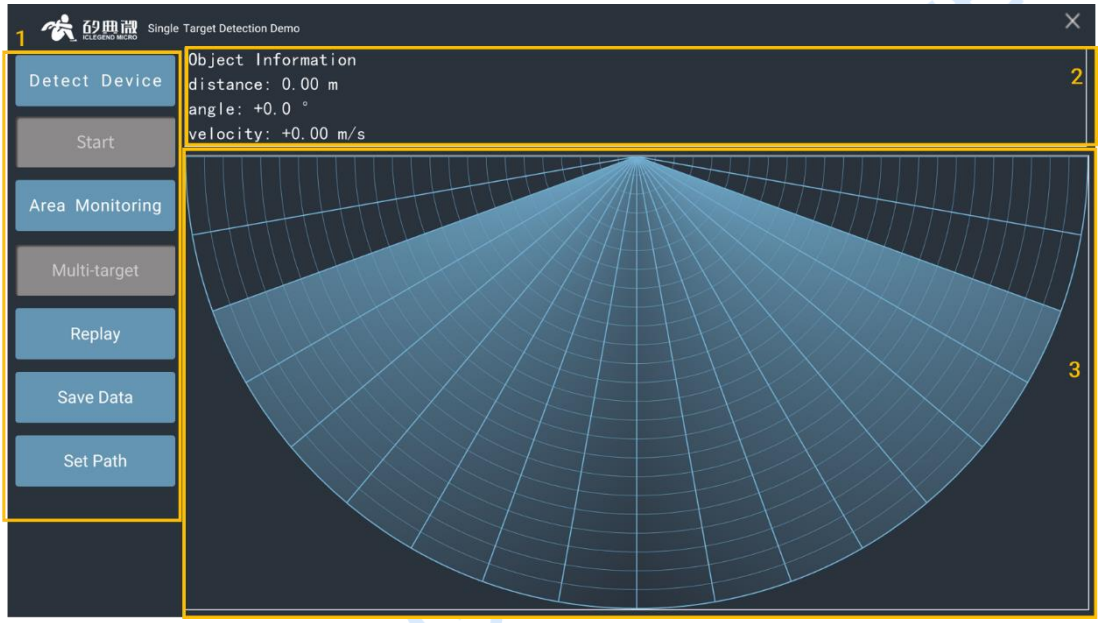



**Figure 4-4 GUI of XenP202TT series designs**

The GUI mainly consists of three zones, they are Functional Button Zone 1, Data Display Zone 2, and Target Demonstration Zone 3. Descriptions of their functions are as follows:

- **Functional Button Zone**:
  - The Detect Device button is to check whether a radar module is successfully connected;
  - The Start/Stop toggle button is to start or stop receiving radar data;
  - The Area Monitoring button is to define monitoring area and blind area;
  - The Multi-/Single-target toggle button is to switch the working mode between single-target and multiple-target detection;
  - The Replay/Stop toggle button is to play back recorded radar data;
  - The Save Data button is to turn on or off the save radar data mode;
  - The Set Path button is to select directory path for saving recorded radar data.
- **Data Display Zone**: to display the distance, angle, and velocity of detected target;
- **Target Demonstration Zone**: to explicitly display the position of the tracked target in detection range.

## 4.2 Software Guide

The software features single and multiple targets tracking demonstration, and allows users to define one or more interested areas on the GUI to monitor that area, as well as set one or more blind area. The software also

support recording, saving and replaying radar data. This section introduces how to use the software.

### 4.2.1 Single-target/Multi-target Detection

Steps for using the software for single or multiple targets detection are as follows:

Step 1: Connect the radar module with a host PC, and open the software following the steps in section 4.1;

Step 2: Click the **Detect Device** button: if the module successfully connected to the host PC, a window writing Serial Port Device Detected will appear, as shown in Figure 4-5, click the **OK** button to continue;

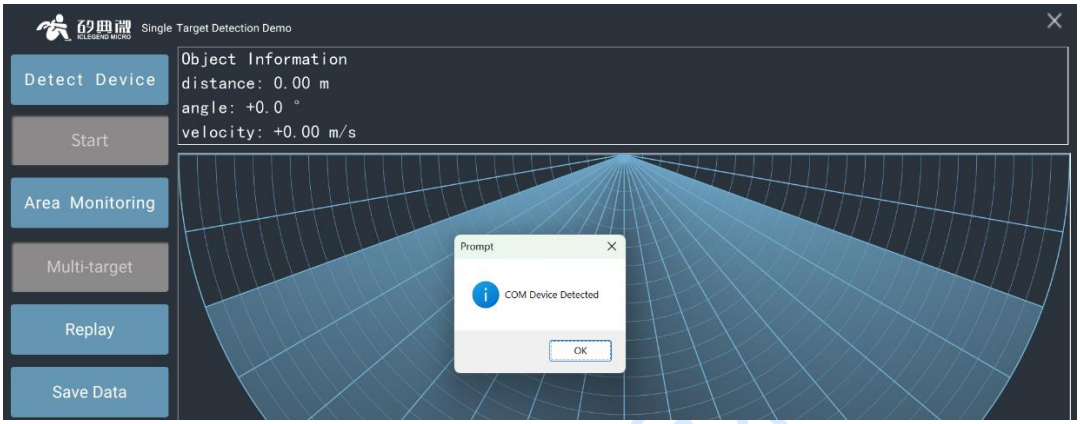



**Figure 4-5 Device successfully detected**

Step 3: Click the **Start/Stop** toggle button, the GUI will display the position of the detected target referring to the radar, an example is shown in Figure 4-6;

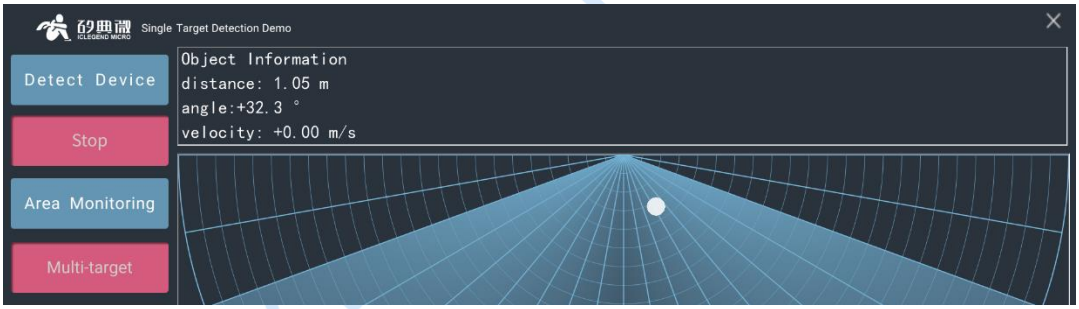



**Figure 4-6 Example of single target detection demonstration**

Step 4(Optional): By default, the software works in Single Target Detection mode, to switch to Multiple Target Detection mode, click the **Multi-target /Single-target** toggle button, the Triple Targets Detection Demo[4] will appear, as shown in Figure 4-7; to switch back to Single Target Detection Mode[5], click the **Multi-target /Single-target** toggle button again.

[4] The Triple Targets Detection Demo shows at most 3 detected targets that with the highest moving energy.

[5] The Single Target Detection Mode is not suitable for positioning and tracking multiple targets.

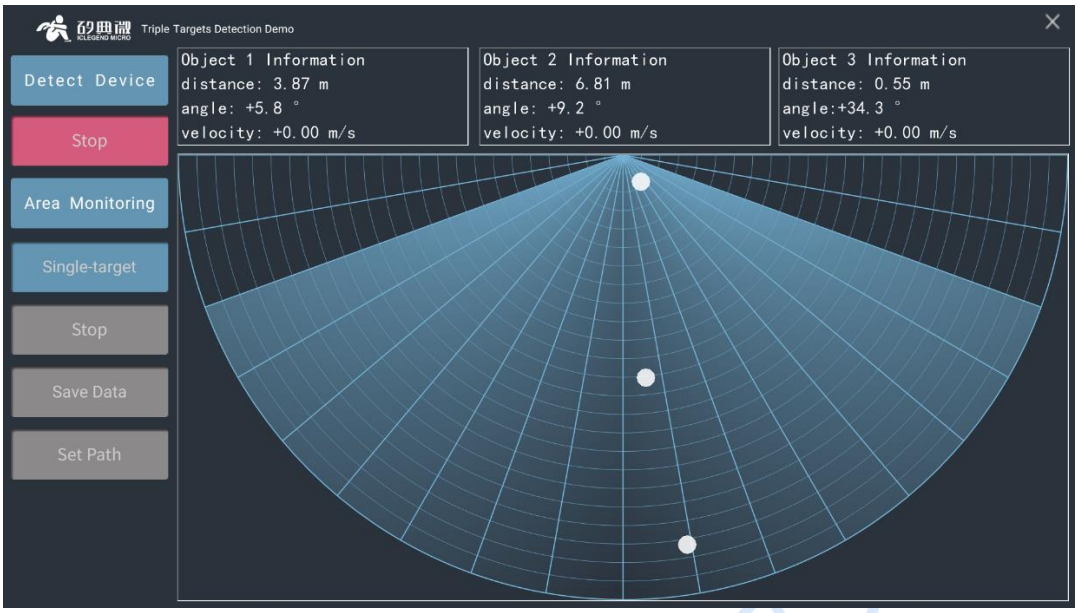



**Figure 4-7 Example of triple-target detection demonstration**

### 4.2.2 Area Monitoring

The software provides Area Monitoring and Blind Area Setting functions.

The Area Monitoring function allows users to set up one or more monitoring areas inside the detection range so that whenever the human target(s) enters the area, the color of the area changes immediately. This function enables the software to selectively present the radar data according to users' interests.

Blind Area setting allows users to define the interested detection and tracking area, and turn off the detection and display of certain range gates. This function enables the software to block certain detection areas according to the parameters that the users set.

Steps for setting up a monitoring area on the GUI are as follows:

Step 1: Connect the radar module with a host PC, and open the software following the steps in section 4.2.1;

Step 2: Click the **Area Monitoring** button, a new window will appear, as shown in Figure 4-8, descriptions of the window are as follows:

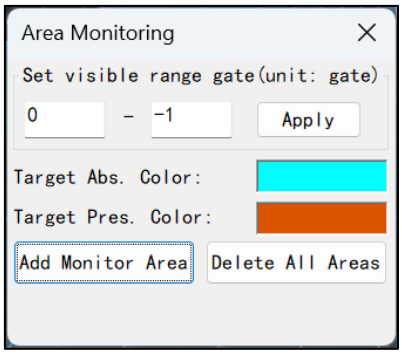



**Figure 4-8 Area Monitoring window**

**Set visible range gate**: default as 0~-1[6], meaning there is no blind area; Users can customize a near-end and a far-end blind area, for example: if users set the visible range gate as 1 ~ 21, there is one range gate blind area in the near-end, and two range gates(23[7] - 21) of blind area in the far-end (each

[6] -1 means the maximum value of the module's range gate.

[7] The maximum value for the range gate of the XenP202TT series designs is 23.

range gate represents 36 cm), then click the **Apply** button, the new detection range is as shown in Figure 4-9 where the red areas represent blind areas.

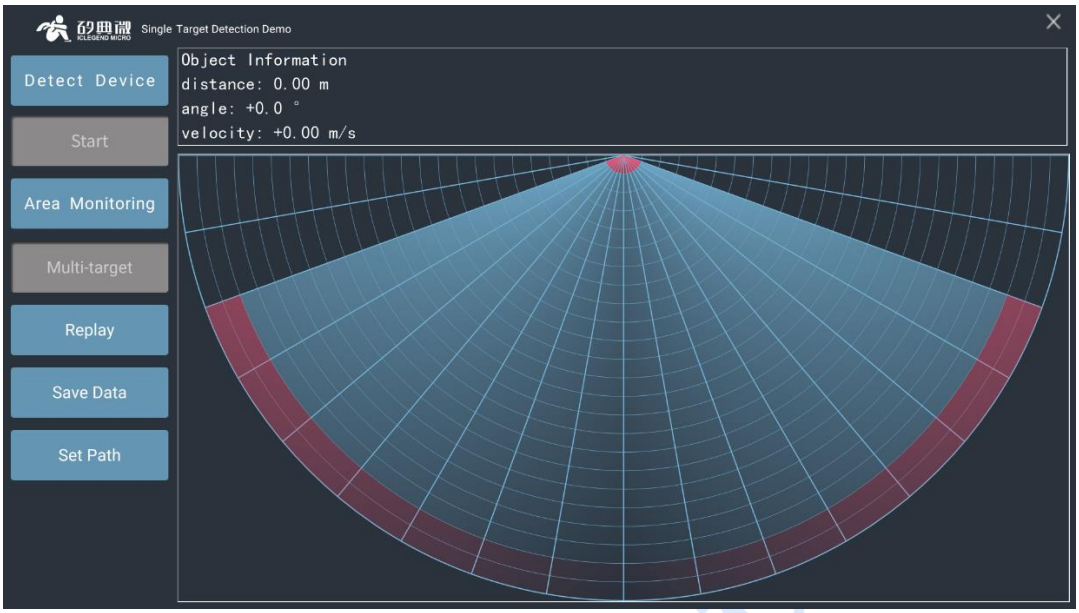



**Figure 4-9 Example of blind area setting**

**Target Abs. Color**: to set the color of the monitoring area when there is no target.

**Target Pres. Color**: to set the color of the monitoring area when there is a target.

**Add Monitor Area**: to start defining a monitoring area, once this button is clicked, users click in the radar chart to add vertex of the monitoring area, and right click to finish this process.

**Delete All Areas**: to delete all the pre-defined monitoring areas.

Step 3: Click the **Add Monitor Area** button to start defining a monitoring area, click in the radar chart to define the vertexes of the desired monitoring area in clockwise or anti clockwise direction, right-click to finish the process, and the GUI will display the defined monitoring area, an example is shown in Figure 4-10; After setting the monitoring area, if a human target is detected in this area, the background color of this area changes immediately, as shown in Figure 4-11 and Figure 4-12.

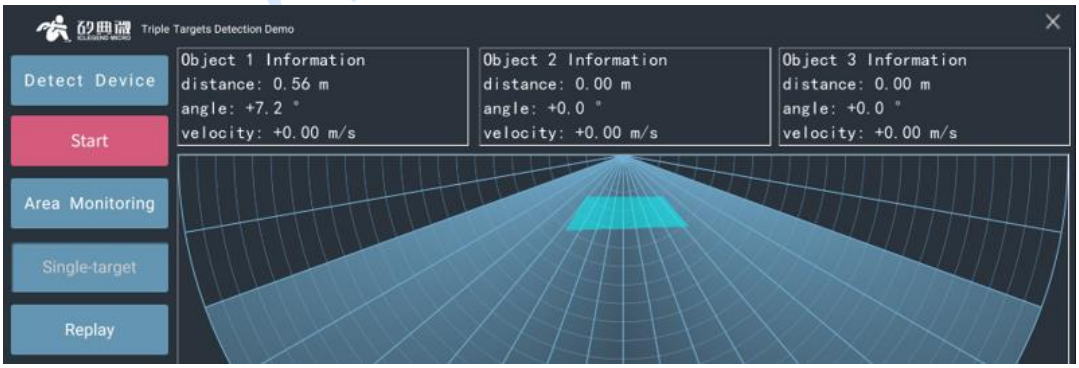



**Figure 4-10 Example of a defined monitoring area**

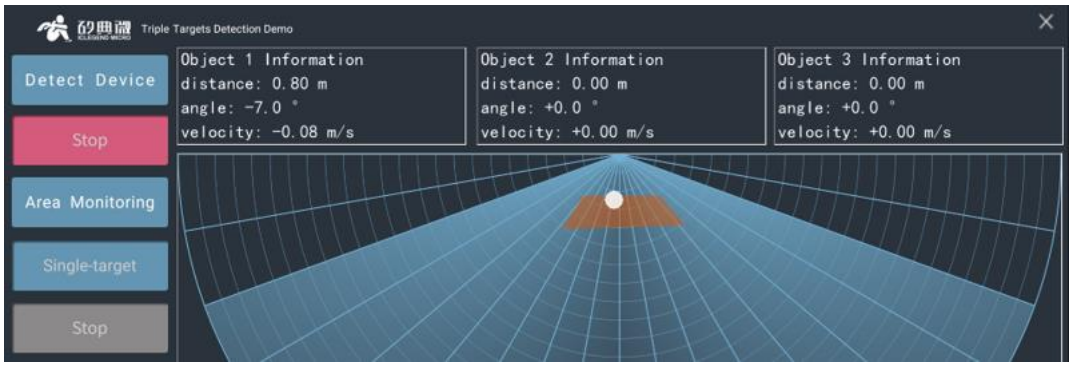



**Figure 4-11 Target exists in monitoring area**

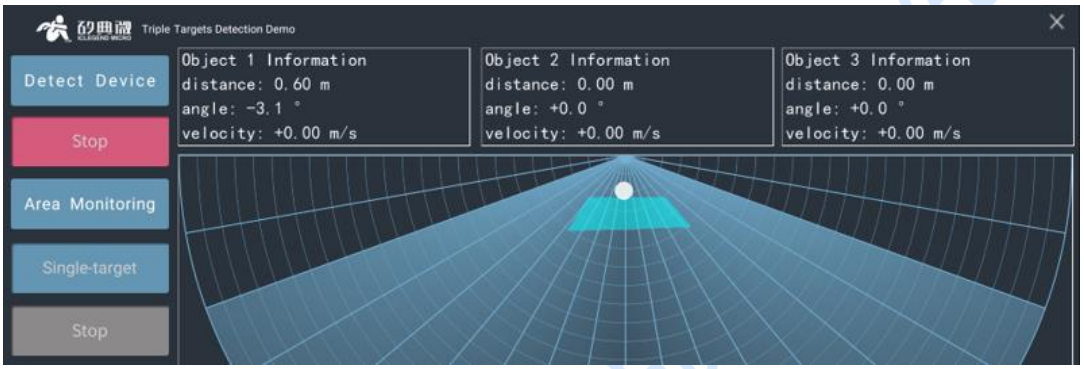



**Figure 4-12 No target in monitoring area**

Step 4(Optional): Repeat Step 3 to set multiple monitoring areas;

Step 5(Optional): If users want to delete all existed monitoring area, click the **Area Monitoring** button, on the Area Monitoring window, click the **Delete All Areas** button to remove all the monitoring areas defined previously.

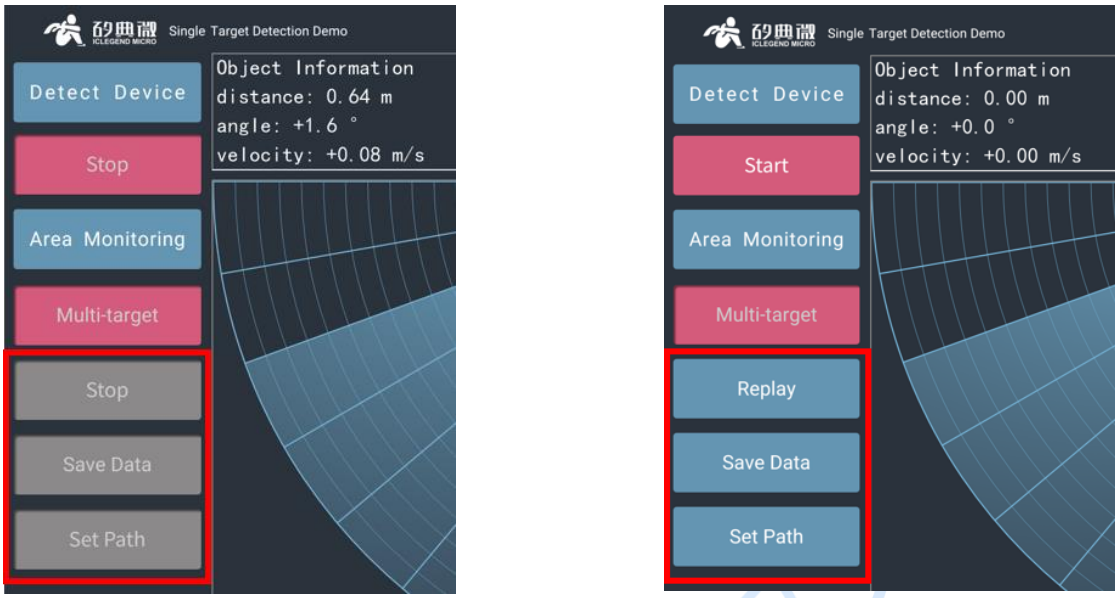
### 4.2.3 Record, Save, and Replay Radar Data

The software supports recording, saving, and replaying the radar data. For the communication protocol of the radar data please refer to 5. Communication Protocol. The steps are as follows:

Step 1: Connect the radar module with the host PC, and open the software following the steps in section 4.1;

Step 2: When the Start/Stop toggle button shows Start, as shown in Figure 4-13 (b), click the **Save Data**[8] button, select the saving path of radar data, by default the folder is named SaveData under the software directory;

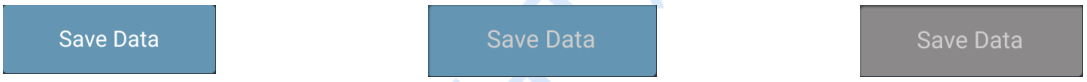
[8] When the **Start/Stop** toggle button displays **Stop**, the **Replay**, **Save Data**, and **Set Path** buttons are all unclickable.




(a) Buttons unclickable (b) Buttons clickable

**Figure 4-13 Radar data replay/save related buttons**

Step 3: By default, the Save Data working mode is off. If users want to turn on the Save Data mode, click the **Save Data** button when the button is clickable (as shown in Figure 4-14(a)); and to turn off the mode, click the **Save Data** button again;




(a) Save Data mode off (b) Save Data mode on (c) Button unclickable

**Figure 4-14 Three states of the Save Data button**

Step 4: When the Save Data working mode is on, click the **Start/Stop** toggle button to detect human target, the software will display the human target information and demonstration in Zone 2 and Zone 3;

Step 5: Click the **Start/Stop** toggle button to stop detection, and users can find the radar data file folder under the directory set in Step 2, the file folder is named after the time stamp of yyyy_mm_dd_hh_mm_ss;

Step 6: Click the **Replay/Stop** toggle button, choose a radar data file folder, then Zone 2 and Zone 3 will start replaying the radar data;

Step 7: Click the **Replay/Stop** toggle button to stop replaying.

## 4.3 IAP Tool Guide

ICLM provides IAP tools[9] for the XenP202TT series modules to update the firmware. Taking the XenP202TT as an example, steps of using this IAP tool are as follows:

Step 1: Download the *XenP202 IAP Tool* pack from ICLM website, unzip the pack and enter the directory;

Step 2: Connect the XenP202TT module with a host PC following the Step 2 in section 4.1;

Step 3: On the GUI of the IAP Tool, click the **Refresh Device** button, choose the COM number of the XenP202TT module, ensure the baud rate is 256000, as shown in Figure 4-15;

[9] The IAP software pack for the reference design XenP202TT is named *XenP202TT IAP Tool*, and those for the specific designs CSP202TT and CSP203TT are *CSP202TT IAP Tool*, and *CSP203TT IAP Tool* respectively.

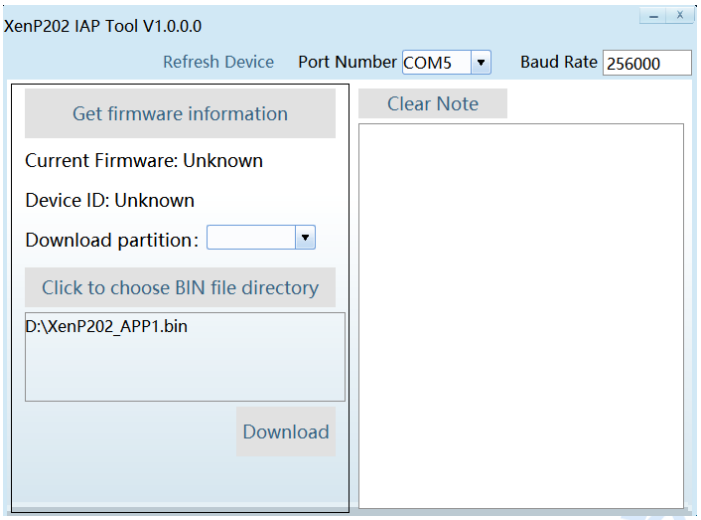



**Figure 4-15 XenP202 IAP Tool**

Step 4: Click the **Get firmware information** button, the GUI will read and display the device ID and the current firmware information of the module. The XenP202TT firmware can run in either partition APP0 or APP1, while it is running in partition APP0, the download partition should be APP1, and vice versa, an example is shown in Figure 4-16;

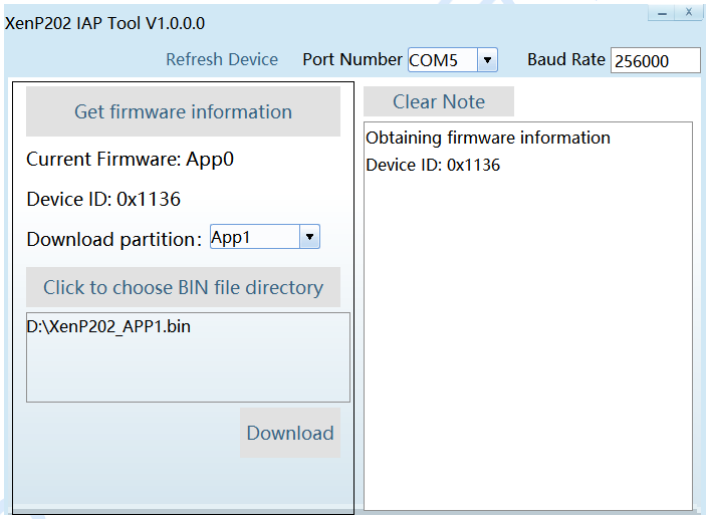



**Figure 4-16 Firmware information**

Step 5: Choose the corresponding download partition, click the **Click to choose BIN file directory** button to select the new firmware bin file. When the download partition is APP0, users should choose the XenP202_APP0.bin file, otherwise choose XenP202_APP1.bin file. Click the **Download** button to start the update, meanwhile the text box on the right starts printing the downloading states.

After successfully updating the firmware, the text box on the right will print "Download successful!", as shown in Figure 4-17. Otherwise, the text box will print the error message.

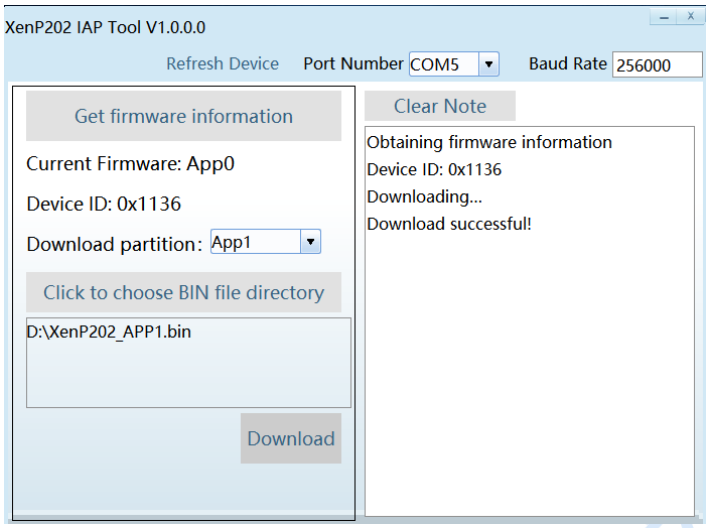



**Figure 4-17 Download Successful**

# 5. Communication Protocol

The communication protocols introduced in this chapter are mainly for users who needs to develop products without the software.

XenP202TT, CSP202TT and CSP203TT communicate with the host PC via the serial port (TTL electrical level). The baud rate of the radar serial port is 256000 by default with 1 stop bit and no parity check digit.

Radar module outputs the detected target information, including x and y coordinates with the radar as the original point (the definition of x and y axis is shown in Figure 5-1, Figure 5-2, and Figure 5-3 with the arrows pointing towards the positive direction), and velocity. The radar data frame format is presented in Table 5-1.

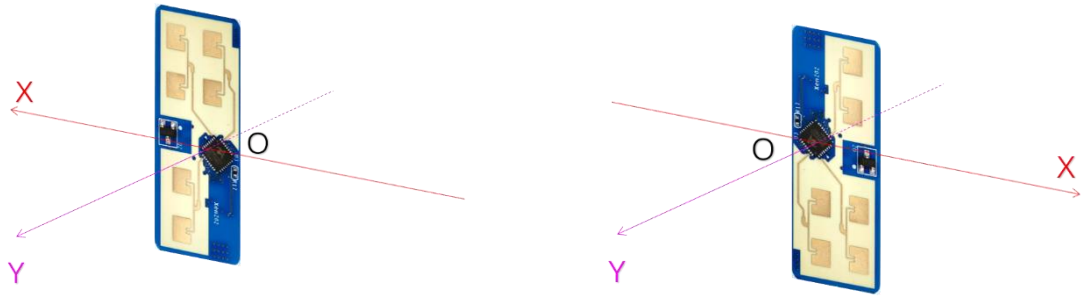
**Table 5-1 Format of radar report data frame**

| Head | Data | Tail |
|---|---|---|
| AA FF 03 00 | Data of Target 1 Data of Target 2 Data of Target 3 | 55 CC |

Data format of each target information is presented in Table 5-2.

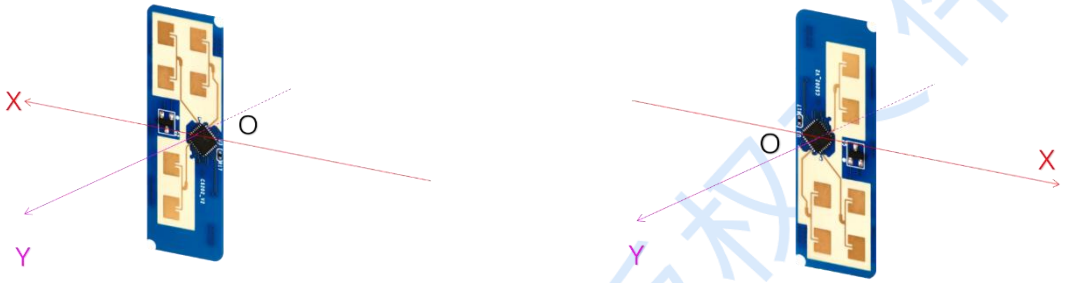
**Table 5-2 Target information within the frame**

| Position x | Position y | Velocity | Range Resolution |
|---|---|---|---|
| signed int16;<br>the highest bit value 1 represents positive of x axis, and 0 represents negative of x axis;<br>the rest 15 bits represents the value of the target on X axis, unit mm | signed int16;<br>the highest bit value 1 represents positive of y axis, and 0 represents negative of y axis;<br>the rest 15 bits represents the value of the target on y axis, unit mm | signed int16;<br>the highest bit value 1 represents positive velocity (leaving the radar), 0 represents negative velocity (approaching the radar);<br>the rest 15 bits represents the value of the velocity, unit cm/s | uint16;<br>represents the value of single range resolution, unit mm |




(a) (b)

**Figure 5-1 Illustration of the coordination system of XenP202TT in recommended poses**




(a) (b)

**Figure 5-2 Illustration of the coordination system of CSP202TT in recommended poses**


(a) (b)

**Figure 5-3 Illustration of the coordination system of CSP203TT in recommended poses**

For example: AA FF 03 00 0E 03 B1 86 10 00 68 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 55 CC

The data above contains target 1 information (blue digits), target 2 and target 3 (correspond to red and black digits) do not exist so the digits are all 0s. The radar module processes this data in a way that described as follows:

Position X of target 1: 0x0E + 0x03 * 256 = 782

0 - 782 = -782 mm;

Position Y of target 1: 0xB1 + 0x86 * 256 = 34481

34481 - 2^15 = 1713 mm;

Velocity of target 1: 0x10 + 0x00 * 256 = 16

0 - 6 = -16 cm/s;

Range sampling length of target 1: 0x68 + 0x01 * 256 = 360 mm.

# 6. Firmware Parameter Configuration

### Modifying Radar Data Report Interval

To modify the data report interval, find the Set_AlgoPara function under the engineering directory \App\algo\src\algopara.c. This function calls the Set_ReportIntervalTime function whose parameter is the radar data report interval, unit is second (s).

### Setting Target Hold Time

In some application scenarios, it requires the radar to maintain detecting and tracking a human target when the target stays motionless, instead of losing the target. The duration of keeping detecting and tracking a motionless target is called Target Hold Time. To set this time, find the Set_AlgoPara function under the engineering directory \App\algo\src\algopara.c. This function calls the Set_HoldCntTime function whose parameter is the target hold time, unit is second (s).

### Setting Detection Range

Users can set the human target detection and tracking range. First, find the Set_AlgoPara function under the engineering directory \App\algo\src\algopara.c. This function calls two functions, Set_RectRange and Set_SectorArea, which are used for defining the human target detection and tracking range of the radar.

Set_RectRange(int16_t xn, int16_t xp, int16_t y): this function defines a rectangle detection and tracking area, an illustration of this function is shown in Figure 6-1. The unit of both parameters is centimeter (cm).

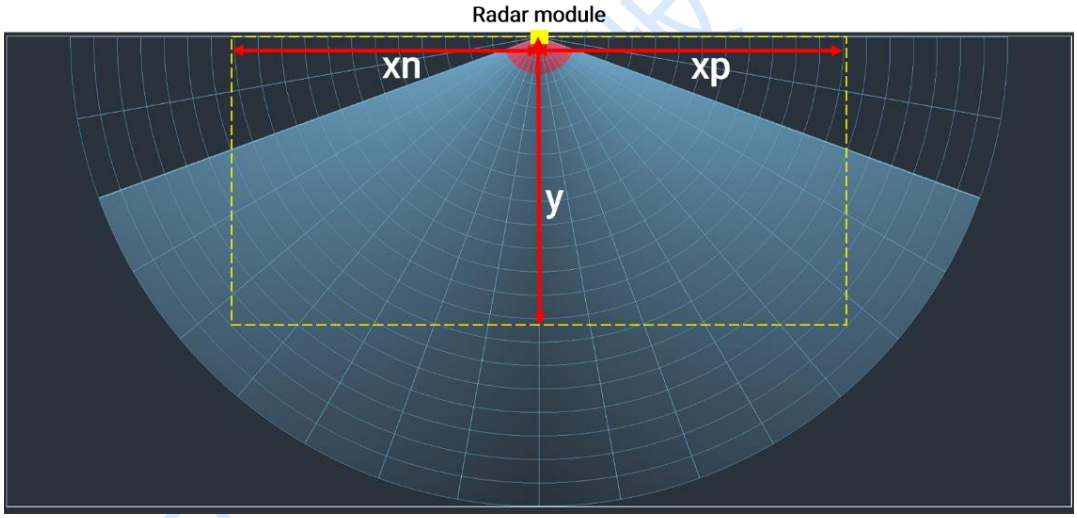



**Figure 6-1 Rectangle detection and tracking range defined by Set_RectRange**

Set_SectorArea (uint16_t distance, uint8_t angle): this function defines a fan-shaped detection and tracking area, an illustration of this function is shown in Figure 6-2. The units of the two parameters are centimeter (cm) and degree (°) respectively.

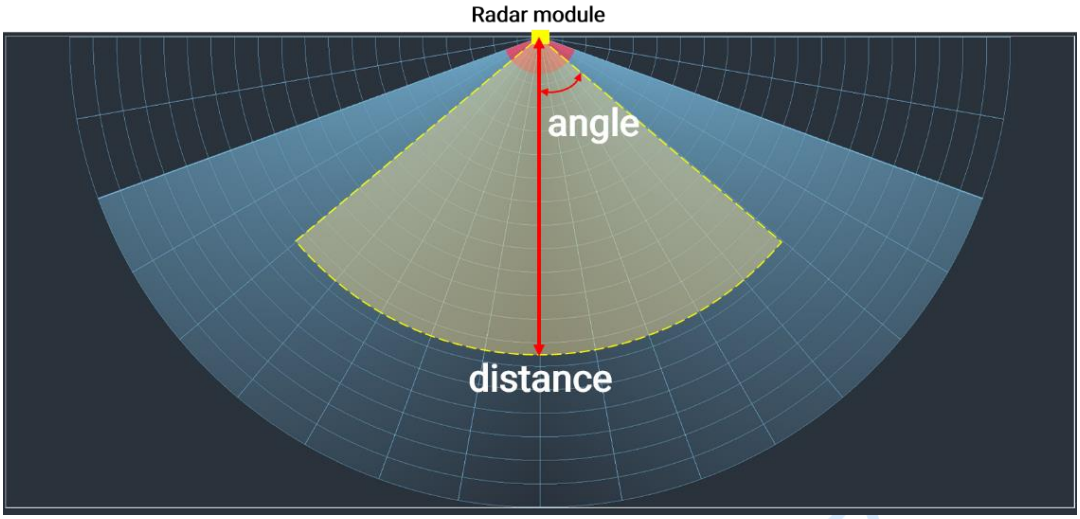



Figure 6-2 Fan-shaped detection and tracking range defined by Set_SectorArea

# 7. Installation and Detection Range

This chapter introduces the recommended installation methods and detection range of XenP202TT, CSP202TT, and CSP203TT.

The XenP202TT series designs are typically wall-mounted, as shown in Figure 7-1. The maximum positioning and tracking range is 8 m. The recommended installation height is 1.5 ~ 2 m, and attention should be paid to objects in the detection range or on top of the ceiling, since they may interfere or disturb the radar.

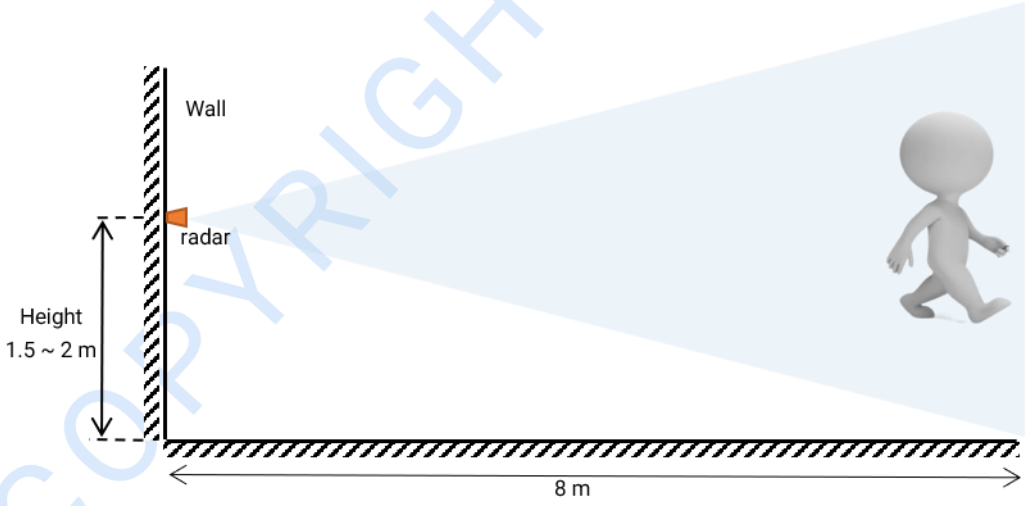



Figure 7-1 Illustration of wall mounted installation

When wall mounted, the recommended installation poses are shown in Figure 7-2, Figure 7-3 and Figure 7-4. The normal direction of the radar antennas is defined as 0°.

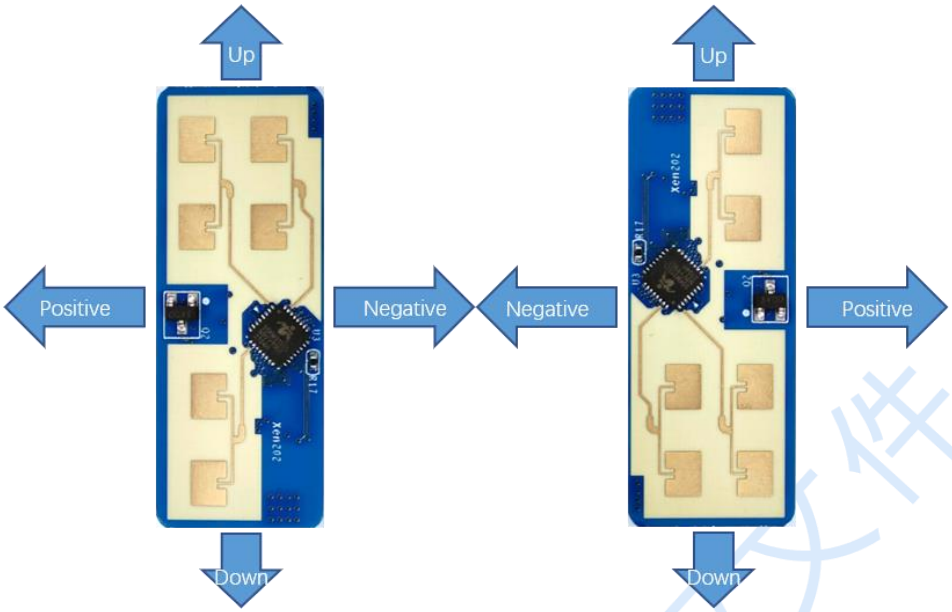



Figure 7-2 Directions of XenP202TT when wall mounted

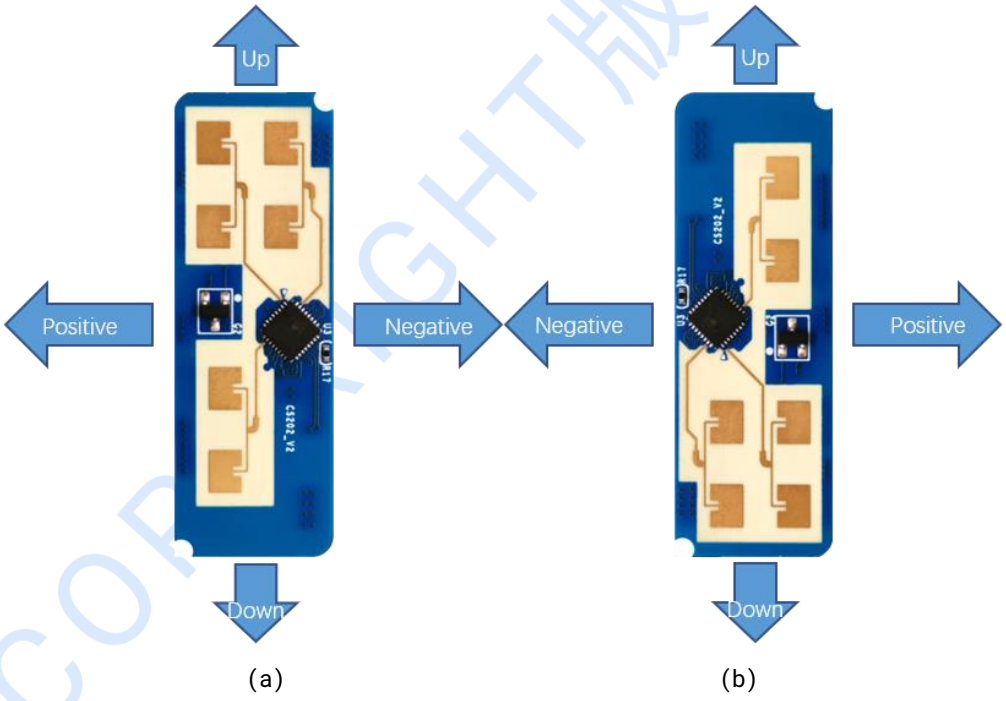



Figure 7-3 Directions of CSP202TT when wall mounted

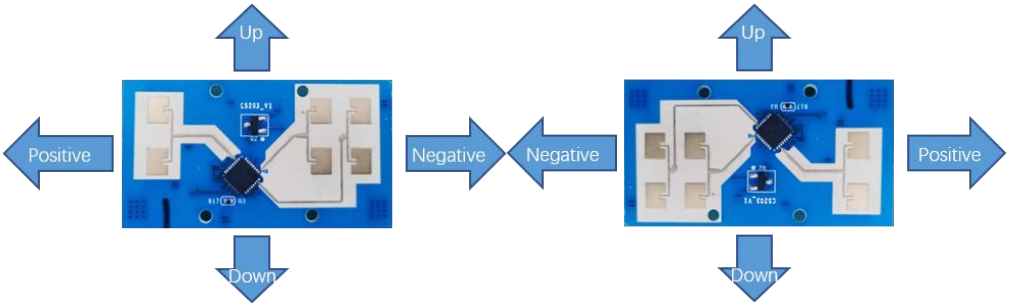



**Figure 7-4 Directions of CSP203TT when wall mounted**

Figure 7-5 shows the detection range of the XenP202TT series radar modules when they are wall mounted at 1.5 m height. The tester is 1.75 m tall and medium sized. Radar detection angle range is ±60° relative to radar normal direction, and the maximum detection range is 8 m in radar normal direction.

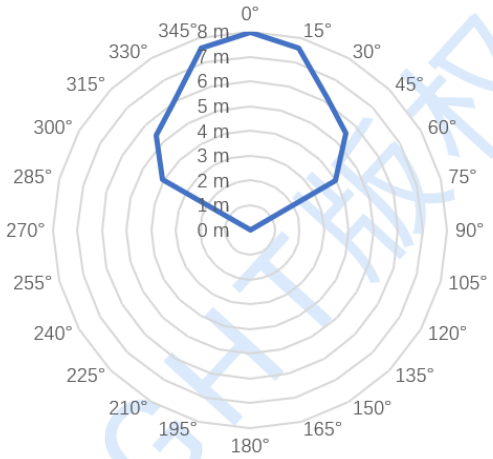



**Figure 7-5 Detection and tracking range of wall-mounted radar**

# 8. Mechanical Size

This chapter introduces the mechanical size of hardware Xen202, CS202_V2, and CS203_V1.

## 8.1 Xen202 Mechanical Size

Figure 8-1 presents the mechanical size of Xen202 hardware PCB. The Xen202 hardware is 40 mm × 15 mm, the board thickness is 1.3 mm with a tolerance of ±10%.

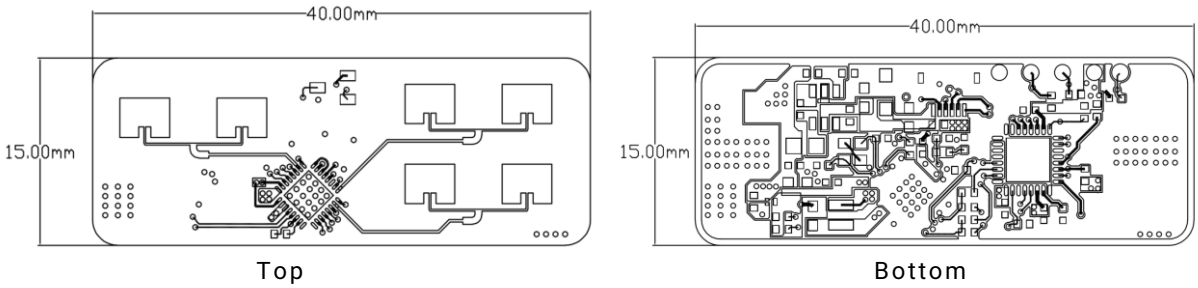



**Figure 8-1 Mechanic size of Xen202**

## 8.2 CS202_V2 Mechanical Size

Figure 8-2 presents the mechanical size of CS202_V2 hardware PCB. The CS202_V2 hardware is 44 mm×15 mm, the board thickness is 1.3 mm with a tolerance of ±10%.

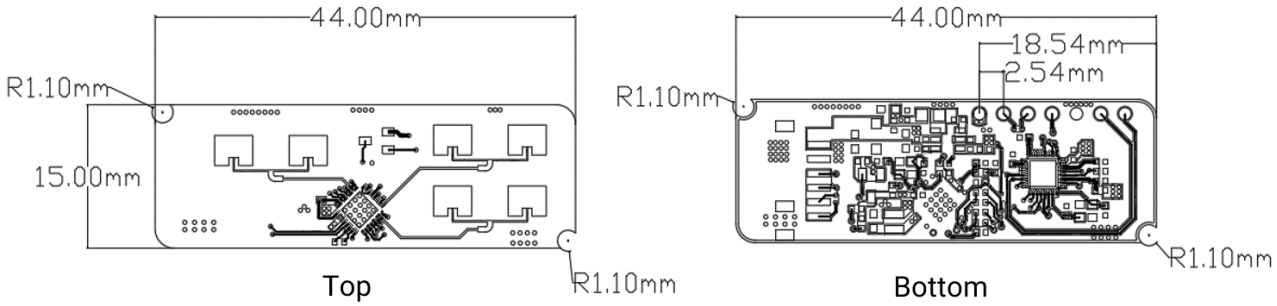



**Figure 8-2 Mechanical size of CS202_V2**

## 8.3 CS203_V1 Mechanical Size

Figure 8-3 presents the mechanical size of CS203_V1 hardware PCB. The CS203_V1 length is 42.0 ± 0.2 mm, the width is 23 ± 0.2 mm, the thickness with the connector soldered is 3.8 ± 10% mm, and the base plate thickness is 1.2 ± 0.1 mm.

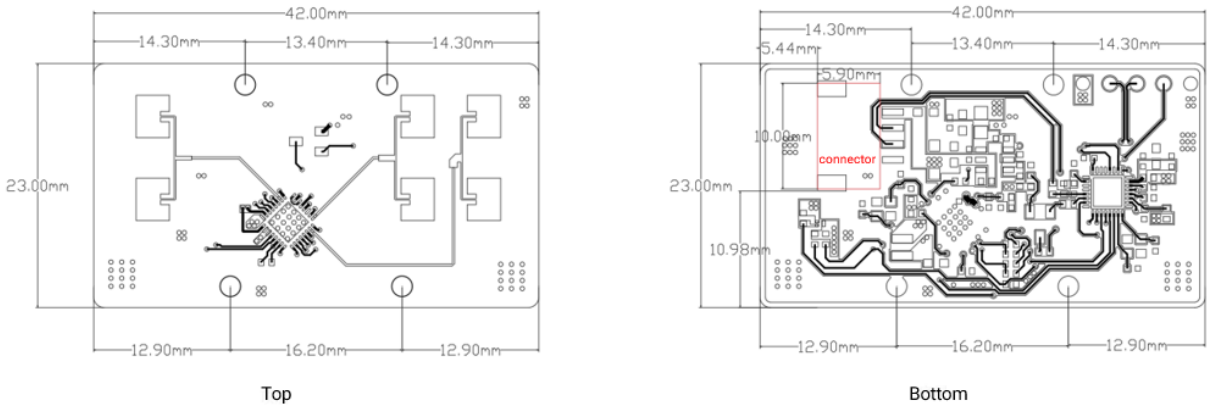



**Figure 8-3 Mechanical size of CS203_V1**

# 9. Installation Requirement

### Radome Requirements

If there is a need to install a radome, the material selected must have good transparency for 24 GHz wave, and do not contain any material that may block electromagnetic wave such as metal. More details please refer to Guide of mmWave Sensor Antenna Radome Design[10].

### Installation Environment

When installing the product, certain requirements should be taken into consideration in case the detection performance is interfered. Features of unsuitable environment are listed below.

- Continuous moving non-human objects in detection area, such as moving animals, swinging curtains, big shaking plants in front of an active vent etc.
- Large strong reflectors will interfere with detection performance when put in front of the antennas.

[10] Currently, only Chinese version is available.

- Interferences of on-ceiling home appliances such as air-conditioners, fans, etc. should be taken into consideration while top mounted.

**Important Requirements**

- Ensure the radar antennas are facing squarely to desired detection area with a clear field of view.
- Ensure the installation position of the sensor is solid and stable. Motion of the radar itself can hugely impact signal processing.
- Ensure there is no object moving or vibrating behind the radar. Motion behind antennas can also be detected due to the penetrability of radar RF wave, thus interferes detection accuracy. It is recommended to use a radome or a backplane to reduce the interference.
- When there are multiple 24 GHz radar installed in close areas, make sure their beamforms do not face to each other, try to separate them as far as possible to avoid interference.

# 10. Important Tips

**Maximum Detection Range, Range Accuracy, and Angle Accuracy**

Maximum detection range, range accuracy, and angle accuracy may slightly fluctuate due to the size, motion state, and RCS of the target.

**Power Supply**

The XenP202TT series modules support both 3.3 V and 5 V power supply, which method is applied depends on whether certain resistors and conductors are soldered on the board, for more details please refer to Chapter 3 Hardware Overview. Additionally, developers should take the EMC design such as ESD and lightning surge of the power supply into consideration when using the XenP202TT series designs.

# 11. Revision History

| Revision | Date | Modification |
|---|---|---|
| 1.3 | 2023/6/30 | Initial release. |
| | | |
| | | |

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